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(54) **Gas-phase growing method and apparatus for the method.**

(57) A gas-phase growing apparatus is provided with a reaction furnace (1), and a substrate (2) having a minute depression is placed inside the reaction furnace (1). In the reaction furnace (1), a reaction gas is supplied onto the substrate, so as to cause gas-phase growth of a layer of a reaction product within the depression of the substrate. The reaction gas is supplied such that the pressure in the reaction furnace is alternately changed between a first pressure and a second pressure. The first pressure is a pressure capable of producing a continuous or intermediate stream in which the collision between the molecules of the reaction gas is predominant, while the second pressure is a pressure lower than the first pressure. The gas-phase growing apparatus is also provided with a pipe (4) for introducing the reaction gas into the reaction furnace, a valve (5) for controlling the flow rate of the reaction gas, a pump (7) for discharging the unconverted reaction gas from the reaction furnace, an orifice (8) for providing flow resistance for the discharge side of the reaction furnace, a pressure meter (6) for measuring the internal pressure of the reaction furnace, and an electromagnetic valve (9) operating in association with the pressure meter.

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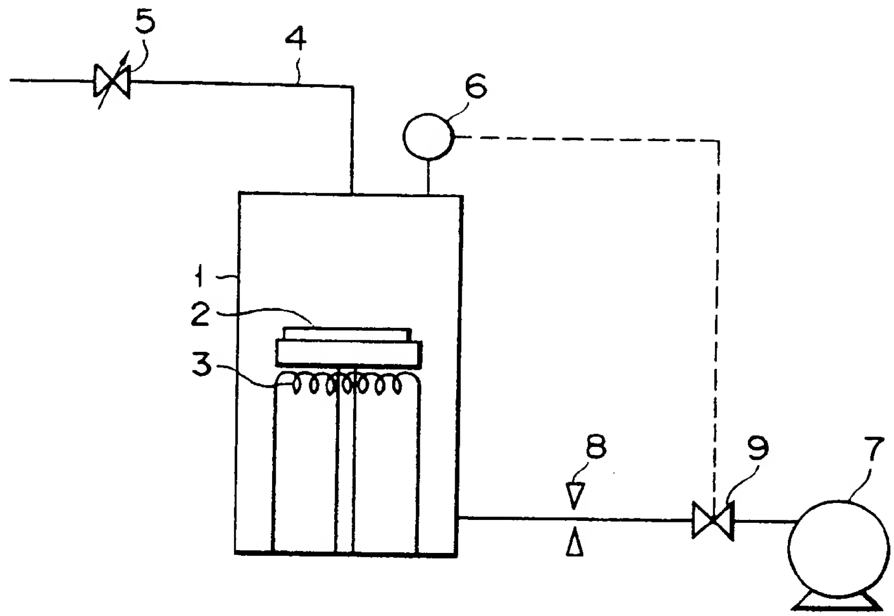


FIG. 1

The present invention relates to a gas-phase growing method used for the manufacture of semiconductor devices, and also to the apparatus employed for the method.

In a conventional CVD apparatus which is in general use, a mixture of a raw gas and a carrier gas is made to flow onto a heated substrate inside a reaction container at a constant rate. An unconverted raw gas is discharged from the reaction container together with the carrier gas. Normally, the CVD apparatus is operated under a constant pressure so as not to disturb the gas stream inside the reaction container.

If a mixed gas containing silane and oxygen is used in the above type of CVD apparatus so as to grow silica (SiO) in a silicon submicron trench (which has come to assume importance in the field of semiconductor devices, such as DRAMs), the problem shown in Fig. 13 occurs. As is shown in Fig. 13, silica 106 grows thick at the inlet 104a of a trench 104 of a substrate 102, while it grows thin in the inside 104b of the trench 104. As a result, a void 105 is left in the inside 104b of the trench 104.

The above problem is related to the size of the trench. If a trench in the substrate is small, like a submicron trench, then the molecules of a gas repeatedly collide against the trench wall when they diffuse into the inside of the trench. Even if a void is not produced, the top surface of the silica formed to fill the trench becomes uneven. A wire cannot be easily connected to such an uneven surface. In addition, H_2O, produced by the reaction between the silane and the oxygen, remains inside the trench, adversely affecting the quality of the resultant semiconductor device.

Recently, it is reported that the problem shown in Fig. 13 can be solved by using a combination of both tetra ethoxyl silane (TEOS) and ozone as a raw gas. Even if this method is effective in solving the problem, the effect is limited to the case where SiO is grown. The method does not provide any guarantee of solution to the problem if a different material, such as SiN is grown.

With the conventional gas-phase growing method and apparatus mentioned above, it is difficult to fill the minute trenches of an uneven-surface substrate with the same or different materials, or flatten the uneven surface of that substrate.

The present invention has been developed in consideration of the above problems, and a primary object of the present invention is to provide a gas-phase growing method and apparatus which enable the minute trenches of an uneven-surface substrate to be uniformly filled with any kind of material or enable the uneven surface of the substrate to be flattened. Another object of the present invention is to remove the gas generated by chemical reaction from the trench.

According to the first aspect of the present invention, there is provided a gas-phase growing method which supplies a reaction gas onto a substrate having a minute trench in a reaction furnace, to thereby form a layer of a reaction product within the minute trench, and in which the supply of the reaction gas is controlled such that the pressure in the reaction furnace is alternately changed between a first pressure capable of producing a continuous or intermediate stream in which the collision between the molecules of the reaction gas is predominant and a second pressure lower than the first pressure.

According to the second aspect of the present invention, there is provided a gas-phase growing method which supplies reaction gases onto a substrate having a minute trench in a reaction furnace, to thereby form a layer of a reaction product within the minute trench, and in which the supply of the reaction gases is controlled such that the pressure in the reaction furnace is alternately changed between a first pressure and a second pressure lower than the first pressure.

According to the third aspect of the present invention, there is provided a gas-phase growing method which supplies a reaction gas onto a substrate having a minute trench in a reaction furnace, to thereby form a layer of a reaction product within the minute trench, and in which acoustic waves are supplied to the substrate.

According to the fourth aspect of the present invention, there is provided a gas-phase growing method which supplies a reaction gas onto a substrate having a minute trench in a reaction furnace, to thereby form a layer of a reaction product within the minute trench, and in which vibrations are supplied to the substrate.

According to the fifth aspect of the present invention, there is provided a gas-phase growing apparatus which supplies a reaction gas onto a substrate having a minute trench in a reaction furnace, to thereby form a layer of a reaction product within the minute trench, and which is provided with a pressure-regulating means for regulating the pressure in the reaction furnace during the gas-phase growth.

According to the sixth aspect of the present invention, there is provided a gas-phase growing apparatus which supplies a reaction gas onto a substrate having a minute trench in a reaction furnace, to thereby form a layer of different reaction products within the minute trench, and which is provided with a means for supplying acoustic waves to the substrate.

According to the seventh aspect of the present invention, there is provided a gas-phase growing apparatus which supplies a reaction gas onto a substrate having minute trenches in a reaction furnace, to thereby form a layer of different reaction products within the minute trench, and which is provided with a means for supplying vibrations to the substrate.

This invention can be more fully understood from the following detailed description when taken in con-

junction with the accompanying drawings, in which:

Fig. 1 is a schematic illustration showing a gas-phase growing apparatus according to the first embodiment of the present invention;

Fig. 2 is a timing chart showing an example of a gas-phase growing method according to the present invention;

Fig. 3 is a schematic illustration showing the advantages of the present invention;

Figs. 4 through 7 are schematic illustrations showing gas-phase growing apparatuses according to the second through fifth embodiments of the present invention, respectively;

Fig. 8 is a timing chart showing another example of a gas-phase growing method according to the present invention;

Figs. 9A-9D are explanatory illustrations showing how gas-phase growth is carried out according to the present invention;

Fig. 10 is a schematic illustration showing a gas-phase growing apparatus according to the sixth embodiment of the present invention;

Figs. 11 and 12 are schematic illustrations showing the seventh and eight embodiments, respectively, in both of which acoustic waves are utilized; and

Fig. 13 is an explanatory illustration showing the problems occurring in conventional gas-phase growth.

Fig. 1 shows a gas-phase growing apparatus according to the first embodiment of the present invention. As is shown in Fig. 1, the apparatus comprises: a reaction furnace 1 in which a substrate 2 is placed and heated; a pipe 4 for introducing a raw gas into the reaction furnace 1; a valve 5 for controlling the flow rate of the raw gas; a pump 7 for discharging the raw gas from the reaction furnace 1; an orifice 8 for providing flow resistance for the discharge side of the reaction furnace 1; a pressure meter 6 for measuring the internal pressure of the reaction furnace 1; and an electromagnetic valve 9 which operates in association with the pressure meter 6. The orifice 8 serves to prevent a reaction product from being scattered in the reaction furnace 1 by providing flow resistance for the discharge side of the reaction furnace 1.

A description will be given of the case where the above apparatus is used for growing polysilicon in a trench of the substrate 2.

First, the electromagnetic valve 9 is opened and the valve 5 is closed, so as to reduce the pressure in the reaction furnace 1. Simultaneous with this, the substrate 2 is heated up to a predetermined temperature

Next, silane (i.e., a raw gas) is introduced into the reaction furnace 1, with the valve 5 gradually opened, until internal pressure P of the reaction furnace 1 becomes equal to P_{min} (P_{min} : an arbitrary pressure). When the length of time Δt_1 has elapsed from the time when the valve 5 is opened, the electromagnetic valve 9 is closed. Thereafter, the operation is carried out according to the timing chart shown in Fig. 2. As is shown in Fig. 2, pressure P increases from P_{min} to P_{max} with the lapse of time Δt_2. Time Δt_3 after pressure P increases to P_{max}, the electromagnetic valve 9 is opened. Time Δt_4 after the electromagnetic valve 9 is opened, pressure P decreases to pressure P_{min}, and time Δt_1 thereafter the electromagnetic valve 9 is closed. With the operations carried out up to this point being regarded as one cycle, the processing is repeated by the necessary number of cycles.

The value of P_{max} is determined by the following formula:

$$P_{max} \geqq 10kT_s/(\sqrt{2}\pi\ell S^2)$$

where Ts is the temperature of the substrate, k is a Boltzman constant, S is the area of a collision cross section of molecules, and ℓ is the width or diameter of a trench.

Pressure P_{max} expressed by the above formula is a condition of the production of a continuous stream. If pressure P_{max} is lower than that pressure or a pressure which produces an intermediate stream, then the gas molecules cannot enter the interior of the trench without repeatedly colliding against the trench wall. If the gas molecules repeatedly collide against the trench wall, a large amount of polysilicon is deposited on the inlet portion of the trench, as in the case of a conventional constant-stream CVD apparatus. If P_{max} is equal to or higher than $10kT_s/(\sqrt{2}\pi\ell S^2)$, the gas molecules collide against one another and can therefore swiftly reach the bottom of the trench. Strictly speaking, it takes a certain time for the gas molecules to reach the bottom of the trench, and more than a certain amount of reaction product is inevitably deposited on the inlet portion of the trench.

However, if pressure P is decreased to a pressure in the range of 0.1 to 50% of pressure P_{max}, namely to pressure P_{min} the raw gas remaining within the trench cannot be easily discharged. The deeper the trench is, the more difficult it becomes to remove the raw gas from the trench. As a result, the raw gas stays inside the trench for a comparatively long time, and the growing speed of a reaction product is high at the bottom of the trench. Therefore, the problem of the conventional technique can be canceled to a certain extent. Further when the time needed to raise the pressure is shortened ($\Delta t_2 + \Delta t_3$), the raw gas is transferred to the bottom of the trench quickly so that the difference in deposition rate between the inlet portion and the bottom portion is minimized not to cause a problem in practice.

According to the present invention, valve 5 may be closed substantially simultaneously when electromagnetic valve 9 is opened. so as to increase the pressure-reducing speed during the operation. If valve 5 is closed when electromagnetic valve 9 is opened, the reaction product can be deposited in a

satisfactory manner, as is shown in Fig. 3.

As described above, the condition which pressure P_{max} should satisfy the following equation:

$$P_{max} \geqq 10kT_s/(\sqrt{2}\pi \ell S^2)$$

From a different viewpoint, this condition can also be expressed as follows:

$$K_n = (\lambda/\ell) \leqq 0.01$$

where K_n is a Knudsen number, λ is a mean free path of molecules, and ℓ is the representative dimension of the opening of a trench (e.g., the diameter or width of the opening of the trench). Therefore, pressure P_{max} is controlled to satisfy the Knudsen number expressed by the above formula.

The condition of the production of an intermediate stream is expressed by:

$$0.01 < K_n = (\lambda/\ell) \leqq 0.1$$

Therefore, pressure P_{max} is also controlled to satisfy the Knudsen number expressed by this formula.

In the case where a continuous stream is produced, the gas molecules hardly collide against the trench wall; the gas molecules diffuse to the bottom of the trench while colliding against one another. In the case where an intermediate stream is produced, some of the gas molecules may collide against the trench wall, but most of them diffuse to the bottom of the trench while colliding against one other. In either case, the collision between the molecules of the raw gas is predominant, and due to this collision the raw gas can reach the bottom of the trench. Consequently, the advantages noted above can be obtained.

Fig. 4 shows the second embodiment of the present invention. As is shown in Fig. 4, a valve 15 and an orifice 12 are provided in a gas-introducing pipe 4, while only an orifice 8 is provided in a gas-discharging pipe (in other words, an electromagnetic valve is not provided for the gas-discharging pipe, as it is in the first embodiment shown in Fig. 1). The alternate switching of pressure is carried out by opening or closing the valve 15 provided in the gas-introducing pipe 4. The purpose for providing the orifice 12 in the gas-introducing pipe 4 is to prevent the pressure in the reaction furnace 1 from rapidly increasing when the valve 15 is opened. In the second embodiment, the gas is constantly discharged from the reaction furnace 1, so that the particles of dust or the like do not flow back into the reaction furnace 1 when the pressure in the reaction furnace 1 increases.

Fig. 5 shows the third embodiment of the present invention. As is shown in Fig. 5, a reservoir tank 20 is provided for a gas-discharge pipe such that the tank 20 is located on the downstream of an electromagnetic valve 9. When the valve 9 is closed, the tank 20 can be maintained in the vacuum state by means of a pump 9. Therefore, when the valve 9 is closed, the pressure in the reaction furnace 1 can be quickly reduced.

Fig. 6 shows the fourth embodiment of the present invention. As is shown in Fig. 6, a reservoir tank 21 is provided for a gas-introducing pipe 4 such that the tank 21 is located on the upstream of a valve 15. Since a gas to be supplied into a reaction furnace 1 can be stored in the tank 21 beforehand, the pressure in the reaction furnace 1 can be quickly increased when the valve 15 is opened.

The third and fourth embodiments shown in Figs. 5 and 6 may be combined with each other. In this combination, the reservoir tanks 20 and 21 are provided for the gas-discharging pipe and gas-introducing pipe, respectively. With this structure, it is possible to quickly raise or lower the pressure in the reaction furnace 1.

Fig. 7 shows the fifth embodiment of the present invention. In the fifth embodiment, SiO is formed within a trench by supplying silane and oxygen into a reaction furnace 1. The gas-phase growing apparatus shown in Fig. 7 comprises two gas-introducing pipes 4a and 4b, one being used for the supply of SiH_4 and the other being used for the supply of O_2. The apparatus is operated according to the timing chart shown in Fig. 8.

Referring to the timing chart shown in Fig. 8, O_2 is supplied into a trench after the pressure in the reaction furnace 1 is reduced. Then, SiH_4 is supplied, with the result that the pressure in the reaction furnace 1 increases. Thereafter, the supply of both the O_2 and SiH_4 is stopped, and the reaction furnace 1 is brought nearly into a vacuum state by means of a pump 7. With the operations carried out up to this point being regarded as one cycle, the processing is repeated by the necessary number of cycles.

Figs. 9A-9D show how the gas-phase growth occurs by carrying out the processing mentioned in the preceding paragraph. Fig. 9A shows the state obtained when low-pressure oxygen is supplied. Fig. 9B shows the state obtained when high-pressure SiH_4 is supplied. As is shown in Fig. 9B, the low-pressure oxygen moves into to bottom region of the trench due to the supply of the high-pressure SiH_4. Fig. 9C shows the state obtained when the SiH_4 diffuses into the oxygen and reacts therewith. As is shown in Fig. 9C, SiO_2, produced by the reaction between the SiH_4 and the O_2, is formed in the bottom of the trench. Fig. 9D shows the state where the unconverted gases are discharged from inside the trench by bringing the reaction furnace 1 nearly into a vacuum state. With this cycle repeated, SiO_2 is grown first on the bottom of the trench and then on the other portions thereof.

It should be noted that the O_2 need not be supplied with its pressure alternately changed between high and low; it may be constantly supplied at a comparatively low pressure.

It should be also noted that the supply of O_2 and that of SiH_4 need not be carried out in a completely alternate manner. Since these gases remain in the reaction furnace 1 for a certain time, the supply time of O_2 and the supply time of SiH_4 may partially overlap

with each other. Further, a time interval may be given between the supply of O_2 and that of SiH_4.

It should be also noted that the order of the supply of O_2 and that of SiH_4 may be reversed, in which SiH_4 is supplied in low pressure and then O_2 is supplied in high pressure.

Fig. 10 shows the sixth embodiment of the present invention. The reaction furnace 1 employed in this embodiment is a vertical diffusion type, and a plurality of substrates 2 are placed inside the reaction furnace 1 and processed simultaneously. The substrates 2 are arranged in the reaction furnace 1 while being vertically spaced from each other by a distance of 5 mm or so. In the sixth embodiment, a raw gas supplied into the reaction furnace 1 uniformly reaches each of the substrates 2, and is discharged from the reaction furnace 1 before the diffusion of the raw gas has an adverse effect on the growth of a reaction product. With this operation repeated, the substrates 2 can be processed in a uniform manner though they are arranged at short intervals. Therefore, the processing can be carried out with high efficiency. In the sixth embodiment, the raw gas is supplied to the substrates 2 in the direction parallel to the substrates 2. Therefore, the substrates 2 are prevented from being blown off by the raw gas introduced.

In order to alternately change the pressure in the reaction furnace 1 between P_{max} (which produces a continuous or intermediate stream) and P_{min} (which is an arbitrary pressure lower than P_{max}), a pressure-regulating means made by a piston and a cylinder may be employed in the sixth embodiment.

According to the first through sixth embodiments mentioned above, a raw material in the state of either a continuous stream or an intermediate stream is supplied to a minute depression of a substrate placed in a low-pressure atmosphere, so that the raw material can be uniformly fed to the minute depression, even to the bottom thereof. In the case where the conventional technique is used, a layer of reaction product is formed at high speed at the inlet portion of a minute depression and in some cases covers the depression, but this problem does not occur in the first through sixth embodiments of the present invention. In addition, due to the pressure-reducing step used in the embodiments, an auxiliary reaction product does not remain inside the depression, as it does in the conventional case. Therefore, the embodiments enable the growth of a thin film free of impurities. Further, even if a plurality of substrates are processed simultaneously, they can be processed uniformly, without reference to the shape of the reaction furnace.

In the present invention, the need to alternately change the pressure of a supply gas or gases between high and low can be eliminated by utilizing acoustic waves. This is because an increase of the alternate frequency of pressure ultimately results in acoustic waves. Where acoustic waves are utilized, the surface of a substrate can be processed under a varying pressure, with no need to turn on or off the valves as in the foregoing embodiments.

When acoustic waves are utilized in the present invention, it is preferable that the absolute value of a pressure variation be increased by application of a low frequency (e.g., a frequency of several tens of Hz). It is also preferable that the wavelength be controlled to correspond to one of the representative dimensions (e.g., the depth) of a trench by application of a high frequency (e.g., a frequency of several tens of MHz), so as to permit the acoustic waves to reach the bottom of the trench.

Fig. 11 shows the seventh embodiment of the present invention, in which embodiment acoustic waves are utilized on the basis of the above technical idea. As is shown in Fig. 11, a pair of speakers 31 are located in the upper region of a reaction furnace 1, and the furnace 1 is surrounded by a sound-shielding wall 32.

In the present invention, almost the same effect as that obtained by alternately changing the pressure of a supply gas or gases can be obtained by vibrating the substrate. More specifically, low or high frequency vibrations are selected based on the same concept as that of acoustic waves.

Fig. 12 shows the eight embodiment of the present invention, in which vibration of the substrate is utilized. As is shown in Fig. 12, an ultrasonic vibration element 33 is attached to the lower end of a rotating shaft used for supporting a substrate 2 so that minute vibrations are added to the substrate.

The present invention is not limited to the embodiments mentioned above, and may be modified in various manners without departing from the spirit and scope thereof when it is put to practical use.

Claims

1. A gas-phase growing method wherein a reaction gas is supplied onto a substrate having a minute depression in a reaction furnace to thereby form a layer of a reaction product within the minute depression,

   said reaction gas is supplied such that the pressure in the reaction furnace is alternately changed between a first pressure capable of producing a continuous or intermediate stream in which the collision between the molecules of the reaction gas is predominant and a second pressure lower than said first pressure.

2. A method according to claim 1, characterized in that said first pressure is determined to satisfy:

   $$K_n = (\lambda/\ell) \leqq 0.1$$

   where K_n is a Knudsen number, λ is a mean free path of molecules of said reaction gas, and ℓ is

the representative width of the depression.

3. A method according to claim 1, characterized in that said second pressure is lower than 1/2 of said first pressure.

4. A method according to claim 1, characterized in that the pressure in the reaction furnace is alternately changed between the first and second pressures by supplying the reaction gas at a constant rate and adjusting the amount of reaction gas to be discharged from the reaction furnace.

5. A method according to claim 1, characterized in that the pressure in the reaction furnace is alternately changed between the first and second pressures by intermittently supplying the reaction gas.

6. A method according to claim 5, characterized in that the amount of reaction gas to be discharged from the reaction furnace is set substantially at a constant value.

7. A gas-phase growing method characterized in that reaction gases of different kinds are supplied onto a substrate having a minute depression in a reaction furnace to thereby form a layer of a reaction product within the minute depression,

said reaction gases are supplied such that the pressure in the reaction furnace is alternately changed between a first pressure and a second pressure lower than said first pressure.

8. A method according to claim 7, comprising:

a first step of supplying a first reaction gas into the reaction furnace;

a second step of supplying a second reaction gas into the reaction furnace to cause the pressure in the reaction furnace to become higher in the second step and in the first step; and

a step of discharging the first and second reaction gases from the reaction furnace.

9. A method according to claim 7, characterized in that each of said reaction gases is supplied in pulsation or stepwise.

10. A method according to claim 7, characterized in that said first reaction gas is supplied continuously, and said second reaction gas is supplied in pulsation or stepwise with a pressure higher than that of the first reaction gas.

11. A gas-phase growing method wherein a reaction gas is supplied onto a substrate having a minute depression in a reaction furnace to thereby form a layer of a reaction compound within the minute depression,

said substrate is supplied with acoustic waves.

12. A method according to claim 11, characterized in that said acoustic waves are low-frequency waves producing a pressure variation whose absolute value is large.

13. A method according to claim 11, characterized in that said acoustic waves are high-frequency waves whose wavelength corresponds nearly to one of the representative dimensions of the depression.

14. A gas-phase growing method wherein a reaction gas is supplied onto a substrate having a minute depression in a reaction furnace to thereby form a layer of a reaction compound within the minute depression,

said substrate is supplied with vibrations.

15. A method according to claim 14, characterized in that said vibrations are low-frequency vibrations producing a pressure variation whose absolute value is large.

16. A method according to claim 14, characterized in that said vibrations are high-frequency vibrations whose wavelength corresponds nearly to one of the representative dimensions of the depression.

17. A gas-phase growing apparatus for supplying a reaction gas onto a substrate (2) having a minute depression in a reaction furnace (1) to thereby form a layer of a reaction product within the minute depression,

said apparatus comprising pressure-regulating means (4, 5, 7-9, 12, 14, 15) for regulating the pressure in the reaction furnace (1) during gas-phase growth.

18. An apparatus according to claim 17, characterized in that said pressure-regulating means includes:

supply means (4, 5, 12, 14, 15) for supplying said reaction gas into the reaction furnace; and

discharge means (7-9) for discharging said reaction gas from the reaction furnace.

19. An apparatus according to claim 18, characterized in that said supply means has a flow resistance-producing member (12) at an intermediate portion thereof.

20. An apparatus according to claim 18, characterized in that said discharge means has a flow

resistance-producing member (8) at an intermediate portion thereof.

21. An apparatus according to claim 18, characterized in that said supply means includes intermittent supply means (5, 15) for permitting the reaction gas to be supplied intermittently.

22. An apparatus according to claim 17, further comprising measurement means (6) for measuring the pressure in the reaction furnace, said pressure-regulating means being controlled in accordance with an output of the measurement means.

23. An apparatus according to claim 18, characterized in that said supply means contains a flow-regulating valve (5, 15) at an intermediate portion thereof and has a supply capacity which is adjustable in accordance with an opening of the flow-regulating valve.

24. An apparatus according to claim 18, characterized in that said discharge means contains a flow-regulating valve (9) at an intermediate portion thereof and has a discharge capacity which is adjustable in accordance with an opening of the flow-regulating valve.

25. An apparatus according to claim 23, further comprising a reservoir tank (21) located upstream of the flow-regulating valve (15).

26. An apparatus according to claim 24, further comprising a reservoir tank (20) located downstream of the flow-regulating valve (9).

27. A gas-phase growing apparatus for supplying a reaction gas onto a substrate (2) having a minute depression in a reaction furnace (1) to thereby form a layer of a reaction product within the minute depression,

said apparatus comprising means (31) for supplying acoustic waves to the substrate.

28. An apparatus according to claim 27, characterized in that said reaction furnace (1) contains a speaker (31) for producing acoustic waves.

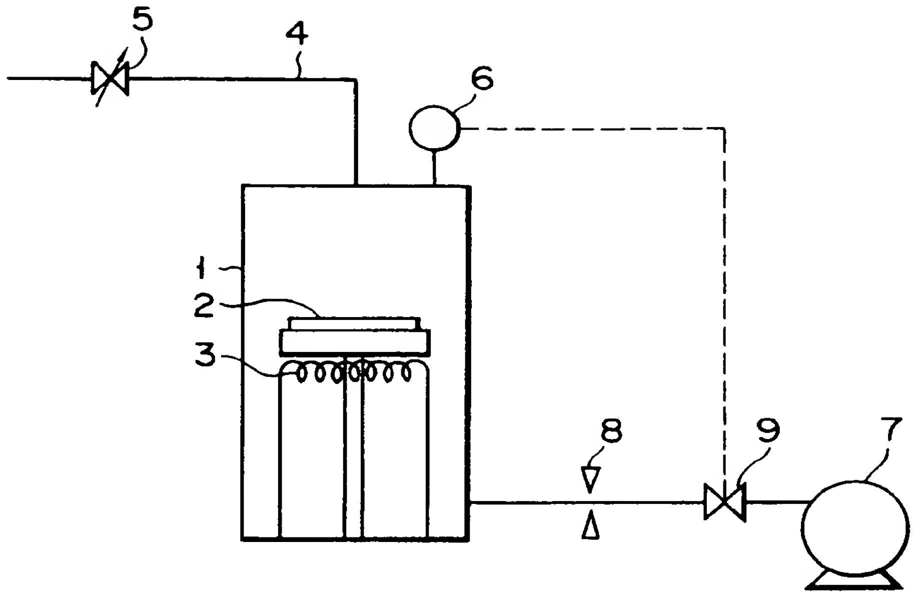
29. A gas-phase growing apparatus for supplying a reaction gas onto a substrate (2) having a minute depression in a reaction furnace (1) to thereby form a layer of a reaction product within the minute depression,

said apparatus comprising means (33) for supplying vibrations to the substrate.

30. An apparatus according to claim 29, further comprising:

support means for supporting the substrate inside the reaction furnace; and

an ultrasonic vibration element (33) connected to the support means.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1
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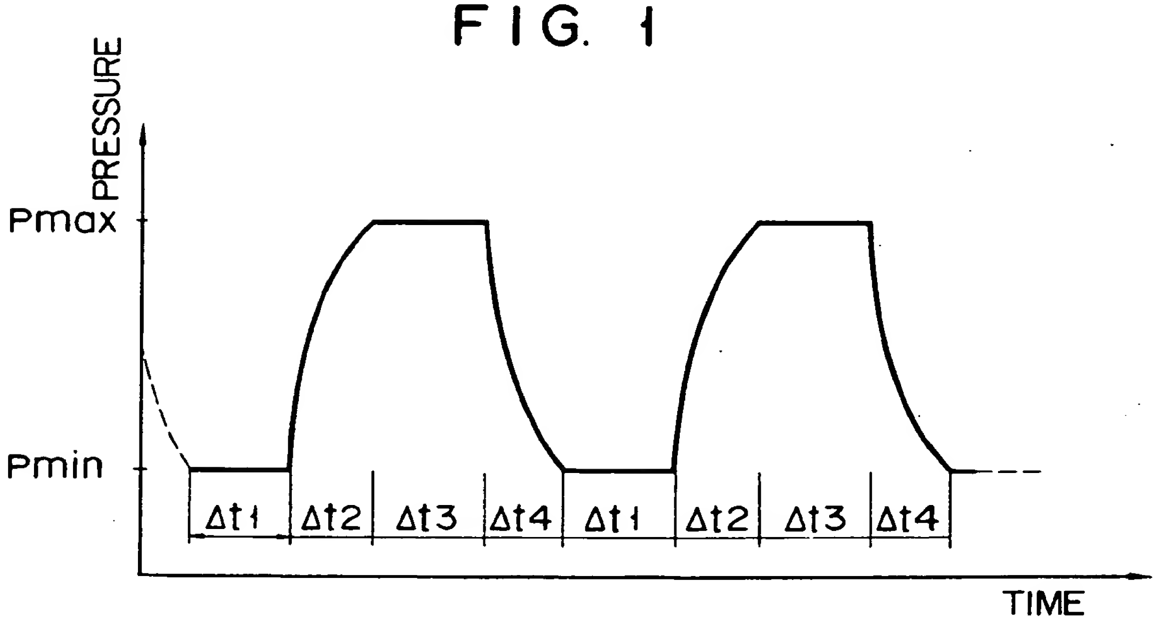
F I G. 1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Pmin
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Δt2
Δt3
Δt4
Δt1
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Δt3
Δt4
TIME

F I G. 2

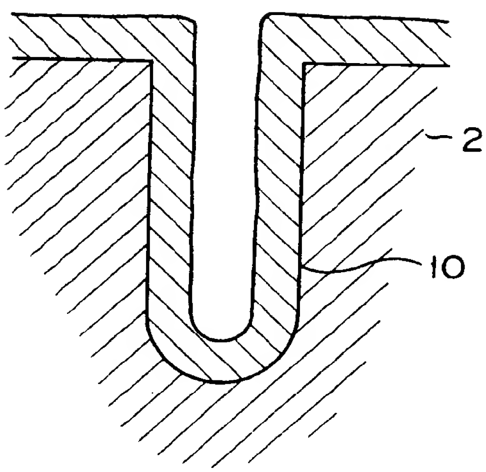


FIG. 3

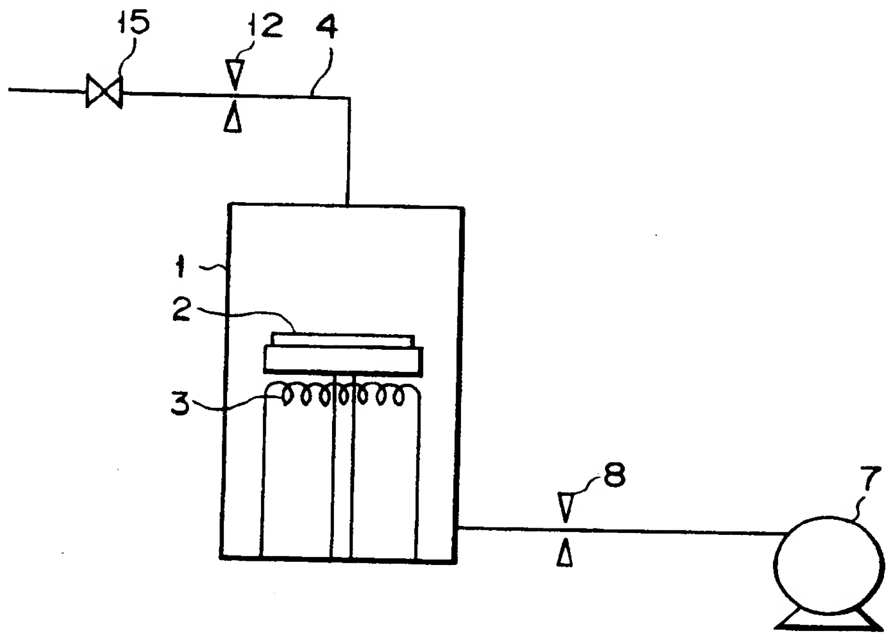


FIG. 4

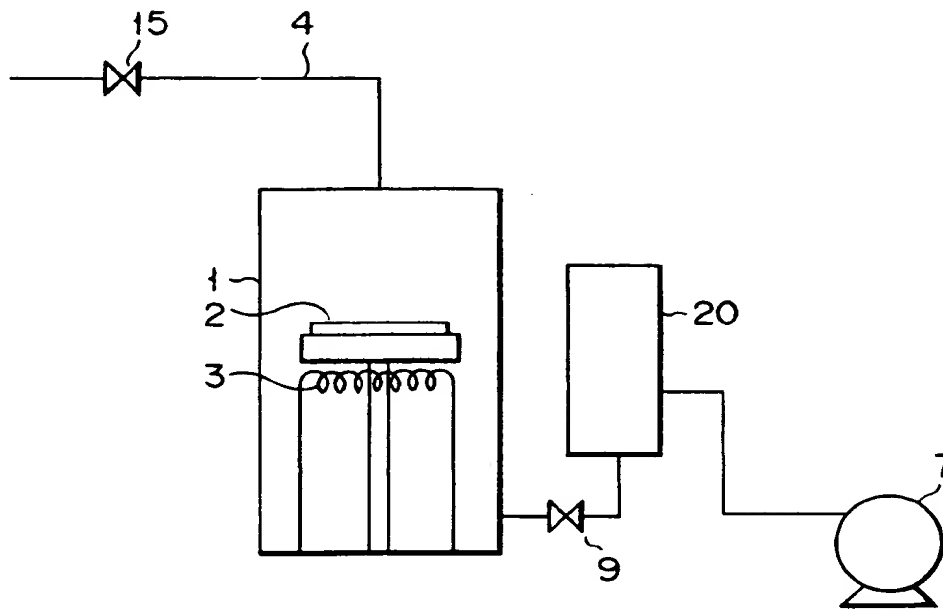


FIG. 5

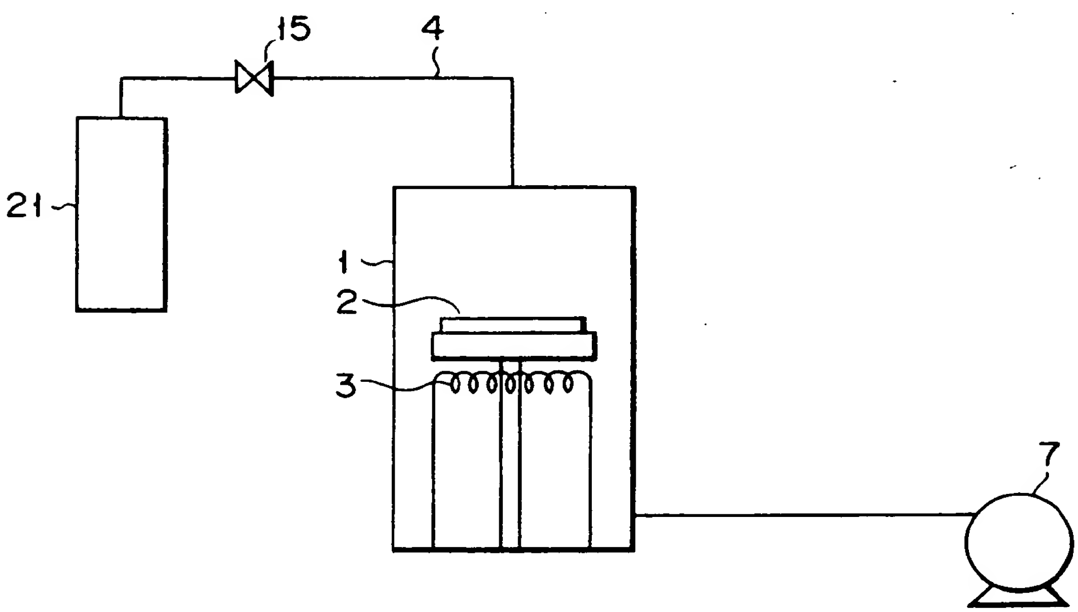


FIG. 6

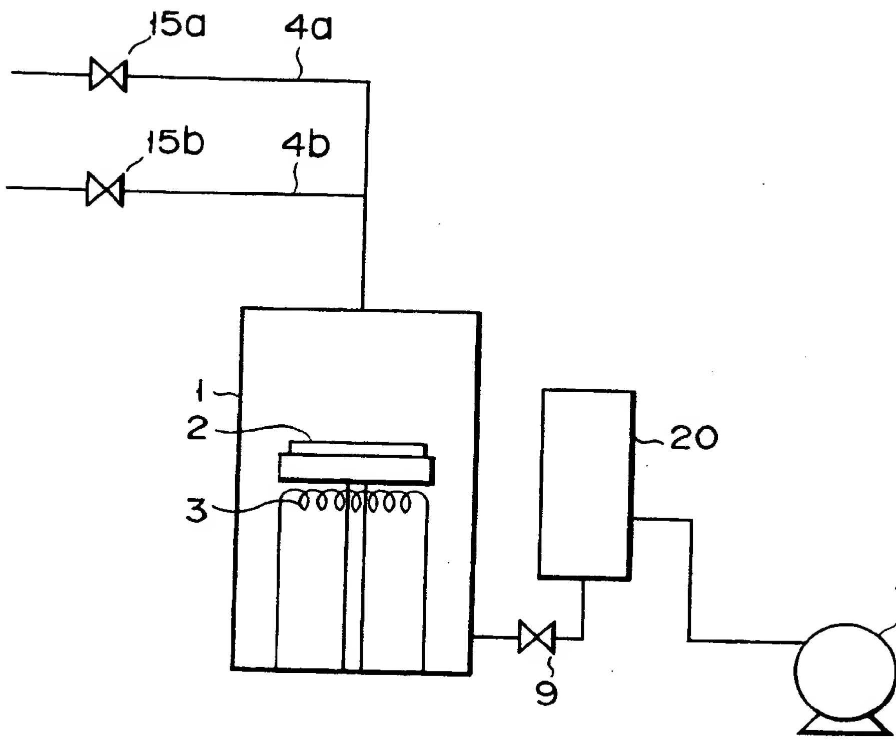


FIG. 7

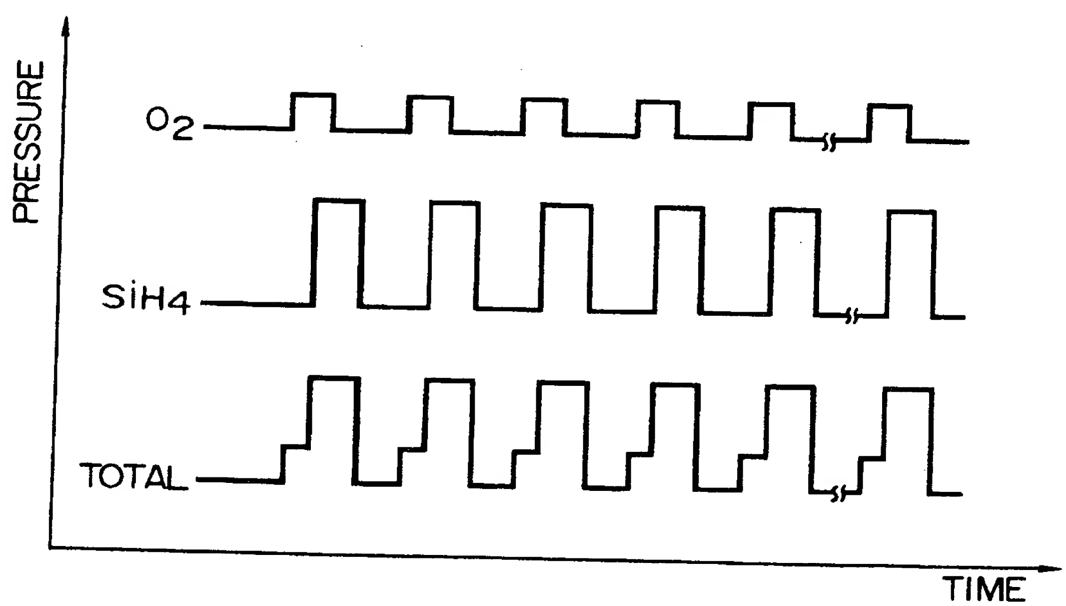


FIG. 8

FIG. 9A

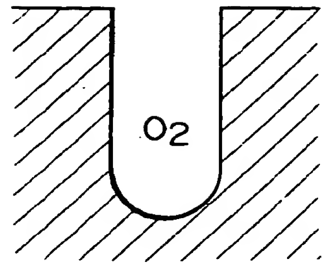


FIG. 9B

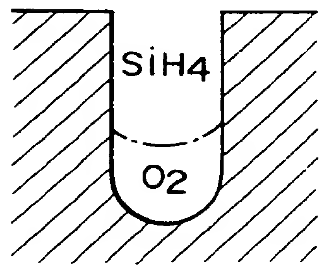


FIG. 9C

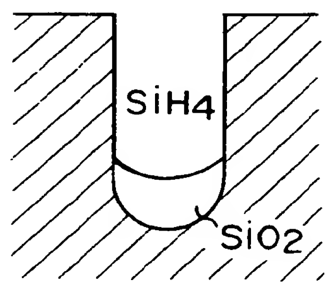
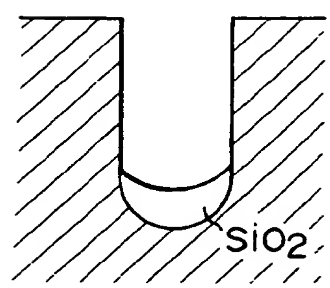
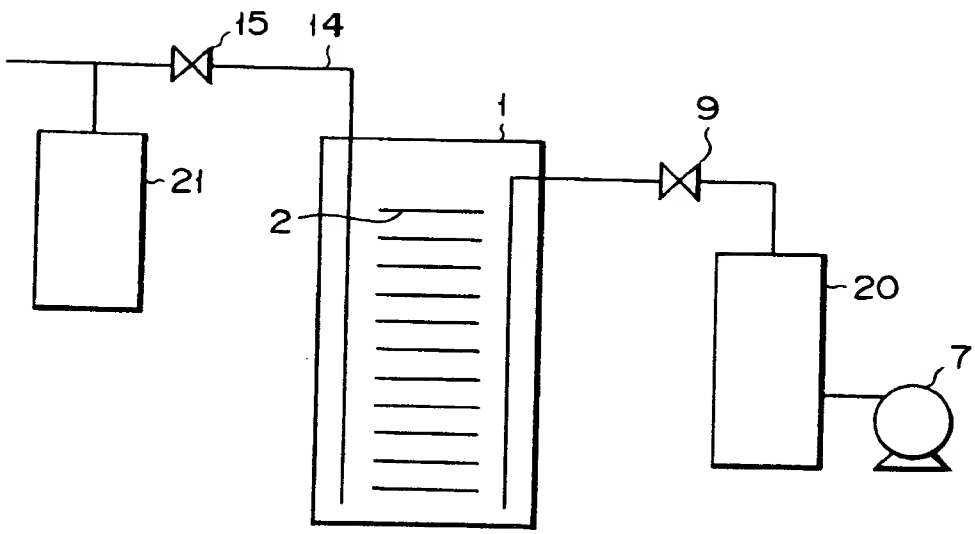
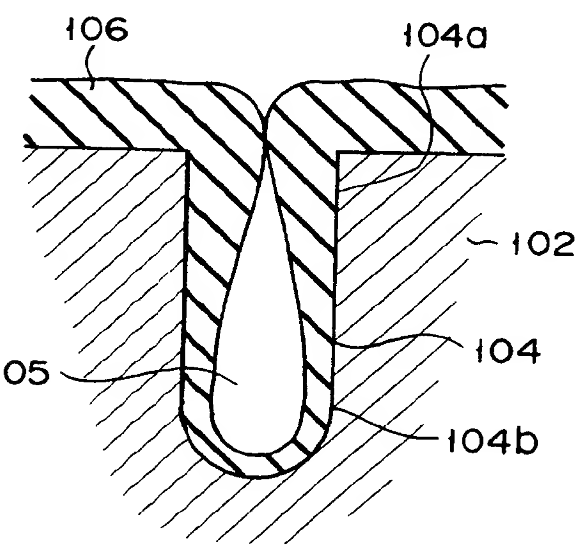


FIG. 9D





F I G. 10



F I G. 13

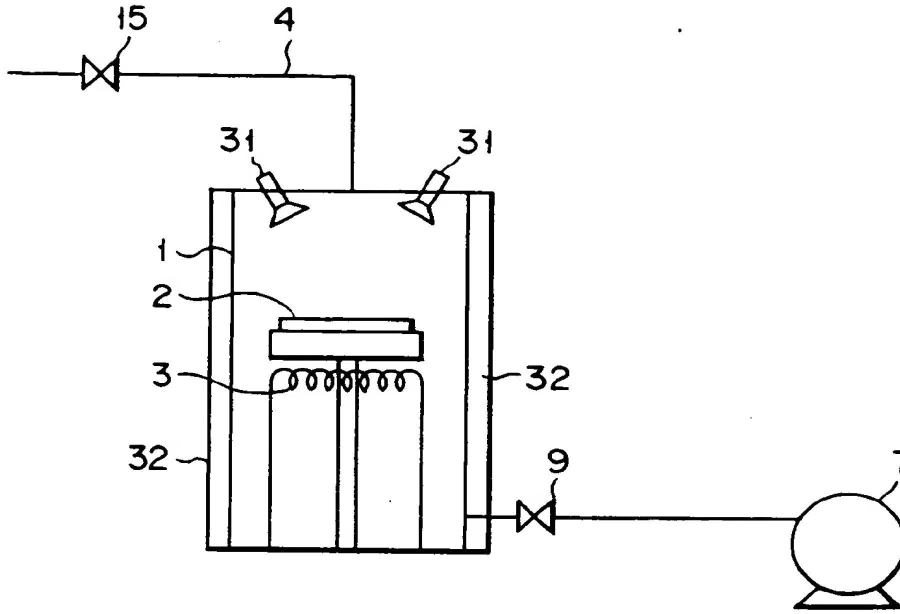


FIG. 11

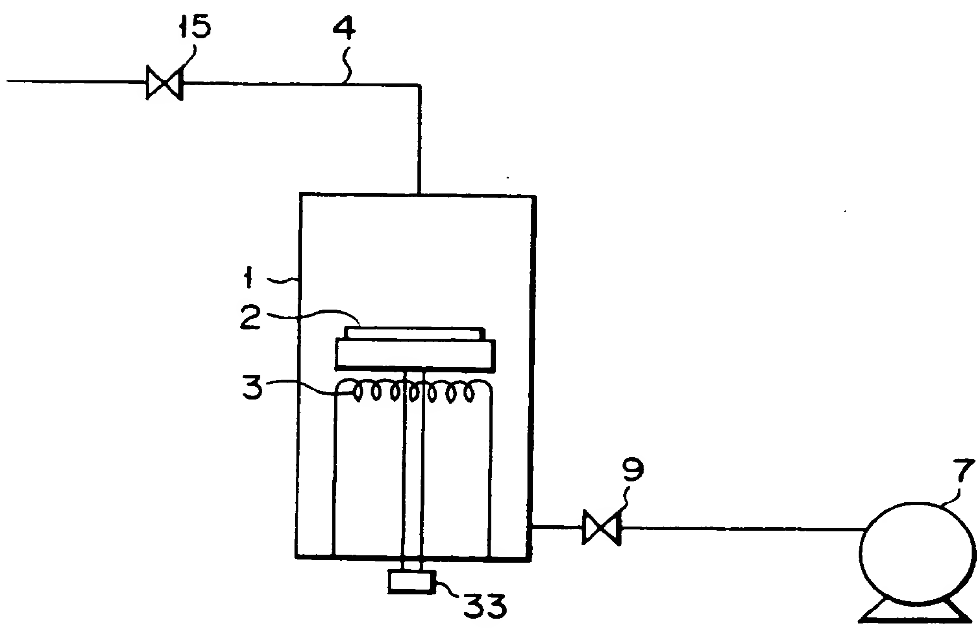


FIG. 12

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 91 30 5748

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	US-A-3 158 499 (JENKIN) * claims 1,2 *	1,5-7, 12,17, 18,21, 27,28	C23C16/04 C23C16/44 H01L21/00
A	EP-A-0 371 854 (MICROELECTRONICS CENTER OF NORTH CAROLINA) * claim 15 *	7-10	
A	JOURNAL OF CRYSTAL GROWTH. vol. 93, 1988, AMSTERDAM NL pages 201 - 206; VAN SUCHTELEN ET AL.: 'THE PULSE REAACTOR - A HIGH-EFFICIENCY, HIGH-PRECISION LOW-PRESSURE MOCVD MACHINE' * figure 1 *	7-10	
A	THIN SOLID FILMS. vol. 158, no. 1, March 1988, LAUSANNE CH pages 123 - 131; SASAKI ET AL.: 'F.C.C. NIOBIUM FILMS GROWN BY HALIDE CHEMICAL VAPOUR DEPOSITION ON ULTRASOUND VIBRATING SUBSTRATES' * figure 1 *	11,29,30	TECHNICAL FIELDS SEARCHED (Int. Cl.5) C23C C30B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	25 OCTOBER 1991	PATTERSON A.M.

CATEGORY OF CITED DOCUMENTS

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